subspecies or varieties, or to determine how many of the named and recorded species will ultimately have to be relegated to the scrap heap and be listed only as synonyms. Still less is the rôle of prophet assumed and an attempt made to go beyond present returns and indicate how many vertebrate species yet remain to be described, although it is believed that in the case of some orders (as, for instance, birds and mammals) reasonably good guesses might be made. The estimate is as follows:

1.	Mammals	7,000
2.	Birds	20,000
3.	Crocodiles and turtles	300
4.	Lizards	3,300
5.	Snakes	2,400
6.	Frogs and toads	2,000
7.	Salamanders	200
8.	Fishes	12,000
	Total	47,200

H. W. HENSHAW

WASHINGTON, D. C.,
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SPECIAL ARTICLES

ON THE SIGNIFICANCE OF VARIETY TESTS

IN the United States, considerable money and effort have been devoted to "variety tests." This has been done upon the assumption that the relative yield of a given variety in one year is a reasonably good criterion of its relative value in a subsequent year. But to some of us, the value of variety tests as they have been carried out by many of our state agricultural experiment stations seems very doubtful.[1]

The utility of a test of n varieties is measured by the correlation between the yields of the individual varieties for different years. If the correlation be 0, the yield of a variety in 1912 furnishes no criterion of its probable productiveness as compared with others in 1913. If the correlation be high, then the prediction of yield from one year's test may be made with great certainty.

Let us apply this test to a series of data given by Hall[2] for eleven years' test of a number of varieties of wheat at Rothamsted. I presume we can look upon these tests as not only more extensive but more trustworthy than many or most of those in experiment station records.

We may assume that, aside from the errors of sampling, two kinds of influences determine observed yield: the innate capacity of the variety and the conditions of growth to which it is exposed—that is, the influences attaching to soil and season. We may correct, in part at least, for the influence of season by determining the mean yield of all the varieties for each year to the nearest tenth bushel and expressing the yield of each variety for that year as a deviation from the general yearly mean. These deviations with their signs show in concrete terms the relative superiority or inferiority of a variety for a given year. Its value agriculturally, of course, depends upon the consistency with which it maintains its superiority from year to year.

Table I. has been prepared from Professor Hall's (which is arranged according to the superiority of varieties as judged at Rotham-

[1] There are several difficulties which have been but poorly met in the problem of variety testing. The identity of the variety must be beyond question, but in many cases there may be grave doubts as to the authenticity of the identifications, and in the absence of herbarium records, it is impossible to correct errors. The organization of scientifically managed seed growers' associations may be expected to overcome this difficulty in large part. Again, varieties differ in their edaphic and climatic requirements. Tests made in one place may give results not at all applicable to other localities with different conditions. Where the tests are made by wide cooperative experiments, this difficulty may be overcome, but when work is confined to a central station its value for a diversified state is *a priori* doubtful. Third, any test is subject to the probable errors of random sampling, and for the most part we have been given no means of estimating the magnitude of this measure of possible untrustworthiness. If the empirical measure of the desirability of a given variety is misleading in a particular year, it is of little value for predicting the probable yield of the variety in a subsequent year!

[2] Hall, A. D., "The Book of the Rothamsted Experiments," p. 66, 1905.

TABLE I.

Deviation of Yields of Varieties from the Yearly Means

	1871	1872	1873	1874	1875	1876	1877	1878	1879	1880	1881	Lots
Rivet (Red)	——	——	+ 9.3	+16.3	+11.6	——	+ 6.7	+14.3	− 4.5	− 1.7	+ 5.7	9
White Chaff (Red)	——	——	+ 1.8	+ 4.4	+ 3.4	+ 7.0	+ 5.5	+ 7.2	+ 2.3	+ 4.0	+ 8.0	9
Club Wheat (Red)	+ 3.8	+ 3.5	+ 8.7	+ 8.9	+ 9.8	+ 5.1	+ 6.6	+ 9.2	+ 3.0	− 7.7	− 3.1	11
Golden Drop (Red) Hallett's	+ 7.3	+ 7.5	+ 5.4	+ 1.1	+ 1.3	+ 5.9	+ 6.6	+ 1.0	+ .5	− 5.2	+ 4.3	11
Bole's Prolific (Red)	+ 1.4	+ .5	+ 6.4	− 2.6	+ 7.5	− 1.1	+ 1.9	+ 1.0	+10.5	+ .4	——	11
Hardcastle (White)	——	+ 4.2	+ 3.2	− 1.1	− 2.9	+ 1.5	− .8	+ 2.2	+ 1.0	+ .3	− .9	10
Red Rostock	+ 4.8	——	+ 7.5	+ 3.1	+ .6	− 2.5	+ 3.5	+ 5.2	−12.0	+ 4.3	− .7	10
Red Langham	− 1.4	+ 1.5	− 4.7	+ 2.4	− 1.9	——	——	− 1.0	+ 5.3	+ 4.5	+ 2.0	11
Bristol Red	− 2.8	+ 2.1	+ .7	+ 2.7	− 5.2	− .1	+ 1.2	+ .3	+ 1.1	+ 6.5	− .3	11
Red Wonder	− 1.0	+ 1.5	− 1.7	+ 4.4	− 3.6	+ 1.7	− 1.3	+ .3	+ 1.5	+ 4.1	− .6	11
Red Chaff (White)	+ .6	− 5.3	− 3.5	− 1.9	− 2.5	+ 1.3	− 1.9	——	——	——	——	7
Browick (Red)	+ 3.1	− 1.8	− .3	+ .4	+ 1.7	− 3.4	− 2.0	− 2.3	+ 3.5	− 4.5	+ .8	11
Casey's White	− 2.3	− .2	− 1.3	+ 1.4	+ 2.2	+ 3.0	+ .1	− 4.0	− 5.1	——	− 3.6	11
Red Nursery	+ 1.9	+ 3.0	−11.7	− 9.6	+ 2.2	− 5.0	− 2.3	− 4.0	+10.4	+ 3.4	− .5	11
Wooly Ear (White)	− 1.0	+ .5	− 1.8	+ .6	− .7	+ 4.1	− 5.3	− 3.5	− .5	− 3.1	− 2.4	11
Burwell (Old Red Lammas)	− 1.1	− 1.0	− 3.7	− 3.4	+ 1.7	− 4.1	− 3.9	− 5.5	+ 6.5	+ 2.9	− 1.7	11
Golden Rough Chaff (Red)	+ .8	− 3.0	− .3	+ 1.4	+ 2.0	− 4.1	− 6.5	− 5.0	− 6.1	+ 7.2	− 4.9	11
Chubb Wheat (Red)	− 3.8	− 2.3	− 3.0	− .2	+ 1.5	− 2.2	− 1.4	+ 3.3	+ .3	− 9.2	——	10
Original Red (Hallett's)	− 2.2	− 7.0	− 2.4	− 7.1	−10.8	− 2.4	+ 1.5	——	——	——	——	7
Victoria White (Hallett's)	+ 1.6	+ 3.0	− .5	− 6.4	− 3.0	− 1.4	− .3	− 7.9	− 5.6	− 8.3	− 2.5	11
White Chiddam	− 5.3	− 3.5	− 7.0	− 8.7	− 4.4	− 5.0	− 5.3	− 2.0	− 8.6	+ 3.3	+ .6	11
Hunter's White (Hallett's)	− 5.3	− 2.5	− .8	− 5.3	−10.4	+ 1.0	− 2.9	− 9.5	− 3.1	− 1.3	——	10
Number of Lots	19	19	22	22	22	22	22	20	20	20	18	226
Averages	32.2	42.3	38.8	50.7	36.8	42.5	42.9	51.8	20.5	24.1	46.5	

sted) in this manner. We note that the deviations in the upper portion of the table are generally positive, while those in the lower half are generally negative. There are, however exceptions even in sign and the magnitude of the deviations varies greatly.

How low the prediction value of a single yield is may be seen at once by correlating between the relative yield of the same variety in different years. Symmetrical intra-class tables[3] or condensed tables may be formed or the coefficient may be calculated from the moments of the deviations of the individual varieties by a convenient formula to be published shortly. We find

$$r = .266.$$

It is most instructive to compare the correlations between the relative yield of the different varieties in the same year. This furnishes a measure of the influence of season.

[3] *Amer. Nat.*, Vol. 45, pp. 566–571, 1911; also a second paper, *Amer. Nat.*, in press.

Table II. shows the deviations of the yields for each year from the mean yield of the variety for all the years it has been grown. That season has an immensely greater influence than variety in determining yield is obvious at once from a comparison of Table II. with Table I. The coefficient of correlation between the deviations of the different varieties from their means in the same year is

$$r = .837.$$

It is evident that with such a relatively low value of the correlation between the yield of varieties in different seasons, little importance can be attached to such "variety tests" as have been generally carried out in Agricultural Experiment Stations. Yet in the future development of breeding, variety testing must hold a most important place in station work, for obviously it is idle to breed new varieties unless they can be certainly demonstrated to be superior to those already existing.

TABLE II

Deviations of the Yield of the Varieties from their own Means in Different Years

	1871	1872	1873	1874	1875	1876	1877	1878	1879	1880	1881	Averages
Rivet (Red)	——	——	+ 2.3	+21.2	+ 2.6	− 3.3	+ 3.8	+20.3	−29.8	−23.4	+ 6.4	45.8
White Chaff (Red)	——	——	− 3.6	+12.8	− 4.0	+ 5.3	+ 4.2	+14.8	−21.4	−16.1	+10.3	44.2
Club Wheat (Red)	− 7.4	+ 2.4	+ 4.0	+ 4.2	+16.2	+ 3.2	+ 6.1	+17.6	−19.9	−27.0	——	43.4
Golden Drop (Red) Hallett's	− 2.8	+ 7.5	+ 1.9	+ 9.5	− 4.2	+ 6.1	+ 7.2	+10.5	−21.3	−23.4	+ 8.5	42.3
Bole's Prolific (Red)	− 7.7	+ 1.5	+ 3.9	+ 6.8	+ 2.5	+ .1	+ 3.5	+11.5	−10.3	−16.8	+ 5.2	41.3
Hardcastle (White)	——	+ 6.1	+ 1.6	+ 9.2	− 6.5	+ 3.6	+ 1.7	+13.6	−18.9	−16.0	+ 5.2	40.4
Red Rostock	− 3.1	——	+ 6.2	+13.7	− 2.7	− .1	+ 6.3	+16.9	−31.6	−11.7	+ 5.7	40.1
Red Langham	− 8.8	+ 4.2	− 5.5	+13.5	− 4.7	+ 2.9	+ 3.3	+11.2	−13.8	−11.0	+ 8.9	39.6
Bristol Red	−10.2	+ 4.8	− .1	+13.8	− 8.0	+ 2.8	+ 4.5	+12.5	−18.0	− 9.0	+ 6.6	39.6
Red Wonder	− 8.3	+ 4.3	− 2.4	+15.6	− 6.3	+ 4.7	+ 2.1	+12.6	−17.5	−11.3	+ 6.4	39.5
Red Chaff (White)	− 6.2	− 2.0	− 3.7	+ 9.8	− 4.7	+ 4.8	+ 2.0					39.0
Browick (Red)	− 3.3	+ 1.9	− .1	+12.5	− .1	+ .5	+ 2.3	+10.9	−14.6	−19.0	+ 8.7	38.6
Casey's White	− 8.2	+ 4.0	− .6	+14.0	+ .9	+ 7.4	+ 4.9	+ 9.7	−22.7	−14.0	+ 4.8	38.1
Red Nursery	− 3.8	+ 7.4	−10.8	+ 3.2	+ 1.1	− .4	+ 2.7	+ 9.9	− 7.0	−10.4	+ 8.1	37.9
Wooly Ear (White)	− 6.6	+ 5.0	− .8	+13.5	− 1.7	+ 8.8	− .3	+10.5	−17.8	−16.8	+ 6.3	37.8
Burwell (Old Red Lammas)	− 6.7	+ 3.5	− 2.7	+ 9.5	+ .7	+ .6	+ .6	+ 8.5	−10.8	−10.8	+ 7.0	37.8
Golden Rough Chaff (Red)	− 4.3	+ 2.0	+ 1.2	+14.8	+ 1.5	+ 1.1	− .9	+ 9.5	−22.9	− 6.0	+ 4.3	37.3
Chubb Wheat (Red)	− 8.2	+ 3.4	− .8	+13.9	+ 1.7	+ 3.7	+ 4.9	+18.5	−15.8	−21.7	——	36.6
Original Red (Hallett's)	− 6.5	− 1.2	− .1	+ 7.1	−10.5	+ 3.6	+ 7.9	——	——	——	——	36.5
Victoria White (Hallett's)	− 2.4	+ 9.1	+ 2.1	+ 8.1	− 2.4	+ 4.9	+ 6.4	+ 7.7	−21.3	−20.4	+ 7.8	36.2
White Chiddam	− 7.9	+ 4.0	− 3.0	+ 7.2	− 2.4	+ 2.7	+ 2.8	+15.0	−22.9	− 7.4	+12.3	34.8
Hunter's White (Hallett's)	− 7.4	+ 5.5	+ 3.7	+11.1	− 7.9	+ 9.2	+ 5.7	+ 8.0	−16.9	−11.5	——	34.3
Number of Lots	19	19	22	22	22	22	22	20	20	20	18	

Is it not time for a concerted and systematic effort on the part of those interested in agricultural science to put this important problem on a sound basis, biologically and statistically?

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COLD SPRING HARBOR, L. I.,
July 17, 1912

THE VISCOSITY OF GASES AND THE BUNSEN FLAME

IN the long experience with the Bunsen flame, which I had some years ago, when these flames were still the only available approach to high temperatures on a large scale, it always struck me as curious that a flame which was quite colorless when the burner was cold should turn whitish when coming from a hot burner. The effect is marked when the combustion gases issue from a long narrow slit, cut from end to end of a horizontal tube 4 inches long. When the cap is removed from the remote end of such a tube, the flame will sputter, showing large excess of air; on closing the tube, it is long narrow pure blue line, burning quietly. When the tube gets hot the flame shows an internal white margin, which again vanishes when the tube is cooled, by water, for instance.

It is clear that for the hot tube there is a deficiency of air, in spite of the excessive room for ingress of air below. Since the gas supplied to the jet remains constant, the intake of air depends upon the rapidity of the escape of gases at the flame. The more rapid the escape, the greater the admixture for the same quantity of gas, and the nearer the flame approached to that of a blast lamp. Hence when the tube at the slot is heated, the escape of gas is retarded owing to the increased viscosity of air at high temperatures. Relatively little air is taken in because the escape of combustion gases is relatively small. This simple experiment, therefore, has a direct and interesting bearing on the viscosity of gases.

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